

M9 2-422603

81361

58-15

R 9

American Rocket Company - HyFlyer Sounding Rocket Program

*American Rocket Company*

# Hybrid Rocket Propulsion for Sounding Rocket Applications

NASA OSSA

November 12, 1991

*American Rocket Company*

## HYBRID ROCKET TECHNOLOGY

- Why Hybrid Rocket Technology ?
- HyFlyer Sounding Rocket

805-987-8970  
CAMARILLO, CA

## American Rocket Company - HyFlyer Sounding Rocket Program

*American Rocket Company*

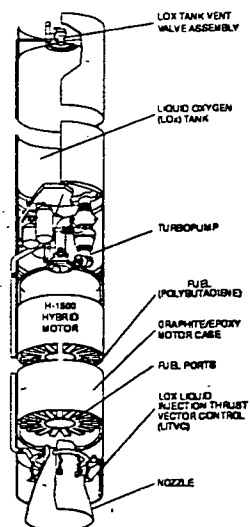
### Why Hybrid Rocket Technology ?

- Hybrid Rocket Fundamentals
- Hybrid Characteristics
- Hybrid Advantages

3

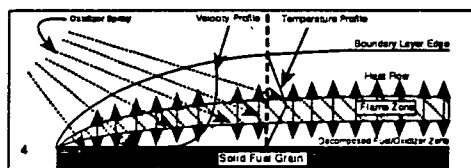
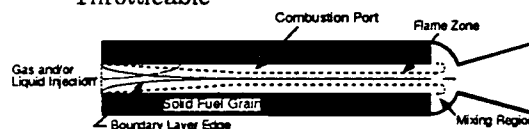
*American Rocket Company*

### Hybrid Rocket Fundamentals



**H-225K Hybrid Motor**

- Solid Hydrocarbon Fuel (e.g., PBD) and Liquid Oxidizer (e.g., LOx)
- Combustion Process
  - Driven by Flow of Oxidizer over Fuel Surface )
- Fuel/Oxidizer Separation
  - Safe
  - Throttleable



4

# American Rocket Company - HyFlyer Sounding Rocket Program

*American Rocket Company*

## **Hybrid Characteristics**

---

- **Safe - Cannot Explode**
  - No Intimate Mixing of Fuel and Oxidizer
  - Combustion Process is Diffusion Limited
- **Throttleable**
  - Thrust Proportional to Oxidizer Flowrate
- **Scaleable**
  - Thrust Scales with Internal Surface Area and Oxidizer Mass Flux
- **Environmentally Clean**
  - Fuel Selection and High Flame Temperature Result in Clean Exhaust Products

5

*American Rocket Company*

## **Hybrid Advantages**

---

- **High Performance**
- **Low Cost Due to Fundamental Safety**
- **Low Cost Due to the Nature of Hybrids**
- **Low Risk**
- **Flexible**

6

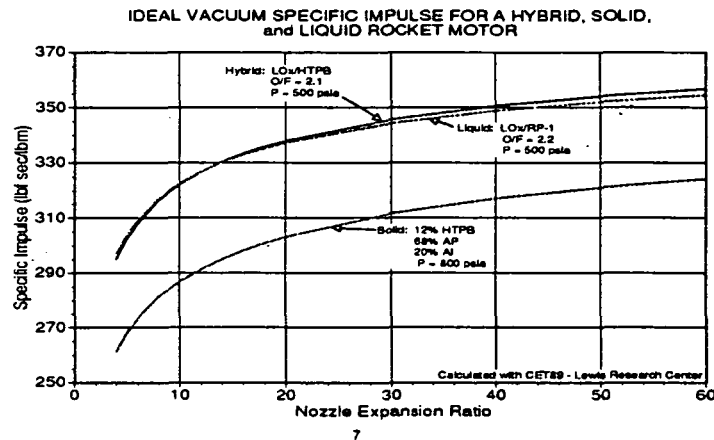
## American Rocket Company - HyFlyer Sounding Rocket Program

### Hybrid Advantages

American Rocket Company

#### High Performance

- $I_{sp}$  is Equivalent to LOx/Hydrocarbon Engines (e.g. Saturn V F-1 1st Stage Engine)--10-15% Higher than Solid Motors
- Throttleability Increases Payload to Orbit



### Hybrid Advantages

American Rocket Company

#### Low Cost Due to Fundamental Safety

- Safe Technology Reduces Costs in All Phases of Development, Production and Operations
- No Remote/Automated Production Facilities Required
- Anomalous Events Do NOT Destroy Test Facilities or Launch Pads
- No Restrictions on Personnel Activity In Any Phase of Development, Production or Operations
- No Special Handling or Transportation Requirements
- Lower Insurance Costs in All Phases

## American Rocket Company - HyFlyer Sounding Rocket Program

### *Hybrid Advantages*

*American Rocket Company*

#### **Low Cost Due to the Nature of Hybrids**

---

- **Low Production Costs**

- Reduced Complexity
- Few Critical Tolerances
- Short Production Cycle (weeks)
- Low Production Facilities Costs



*Standard Light  
Industrial Facilities  
Are Adequate*

- **Low Materials Costs**

- No Strategic Materials
- Multiple Commercial Sources
- Many Material Options

- **Low Operations Cost**

- Reduced Manpower Requirements
- Reduced Inspection Requirements

9

### *Hybrid Advantages*

*American Rocket Company*

#### **Low Risk**

---

- **Non-Explosive Therefore No Catastrophic Detonations**
- **Command Shutdown In the Event of Problems Affords Safe Abort**
- **Safe Engine Idle Allows Engine Verification Prior to Full Thrust**
- **Insensitive to Environmental Conditions**
- **Robust Combustion Cycle**
  - Resistant to Manufacturing Defects
  - Self-Damping
- **Safety = Less Complexity = High Reliability**
- **No Uninsurable Liability**
- **No Hazardous Materials and Clean Exhaust = No Environmental Risk**

10

## American Rocket Company - HyFlyer Sounding Rocket Program

### *Hybrid Advantages*

*American Rocket Company*

#### **Flexible**

---

- **Rapid Response to Customer Requirements**
  - Simple Designs Allows Product Customization
  - Short Development Cycle (Months)
- **Facilitization**
  - Commercial Production Facilities and Short Lead Time Parts Permits Buildup of Production Capability to Match Demand
- **Surge Capability**
  - No Specialized Manufacturing Equipment
  - No Long Lead Time Items
  - No Strategic Materials

11

*American Rocket Company*

#### **Why Haven't Hybrids Been Used Before ?**

---

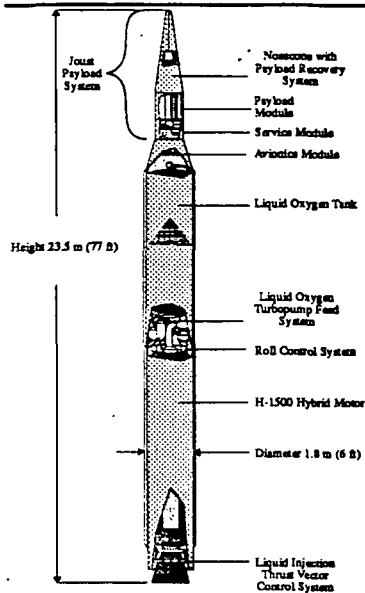
- **Initial Difficulty in Maintaining Stable Hybrid Combustion**
- **Early Focus on "Performance At Any Cost"**
  - Designs Optimized for Maximum  $I_{sp}$
  - Military ICBM Requirements Drove All Initial Designs
- **Initial Emphasis on Solids Based on System Readiness**
  - ICBM Requirement
- **Liquids Developed Intensively For Apollo Program**
- **Larger Database on Solids and Liquids Made Hybrids Higher Risk Option for Later Programs**
- **Large Investment in Facilities to Produce and Test Solids and Liquids Supported Predisposition to Those Technologies**

12

# American Rocket Company - HyFlyer Sounding Rocket Program

American Rocket Company

## The HyFlyer Suborbital Vehicle

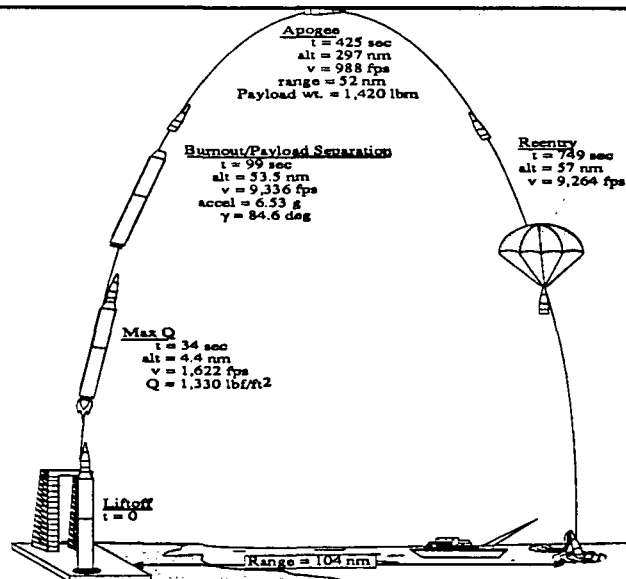


- Provides 11 Minutes of Microgravity Time for a Joust-class Payload
- Based on AMROC H-1500 Liquid Oxygen/Polybutadiene Hybrid Rocket Motor
- In Development to Validate H-1500 Motor for Use in Aquila Orbital Vehicle

13

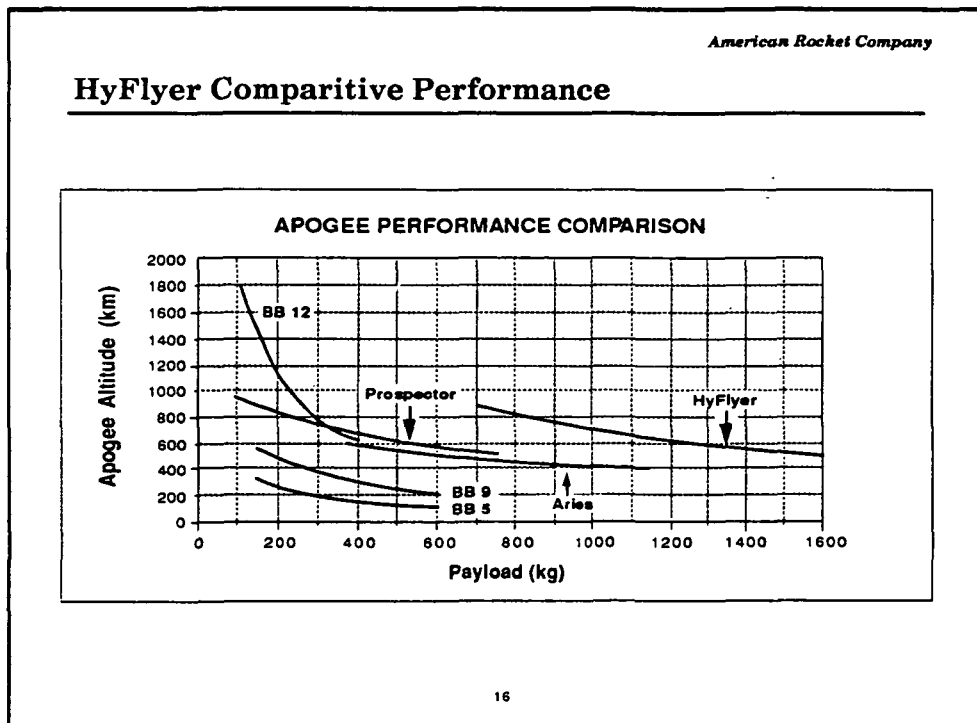
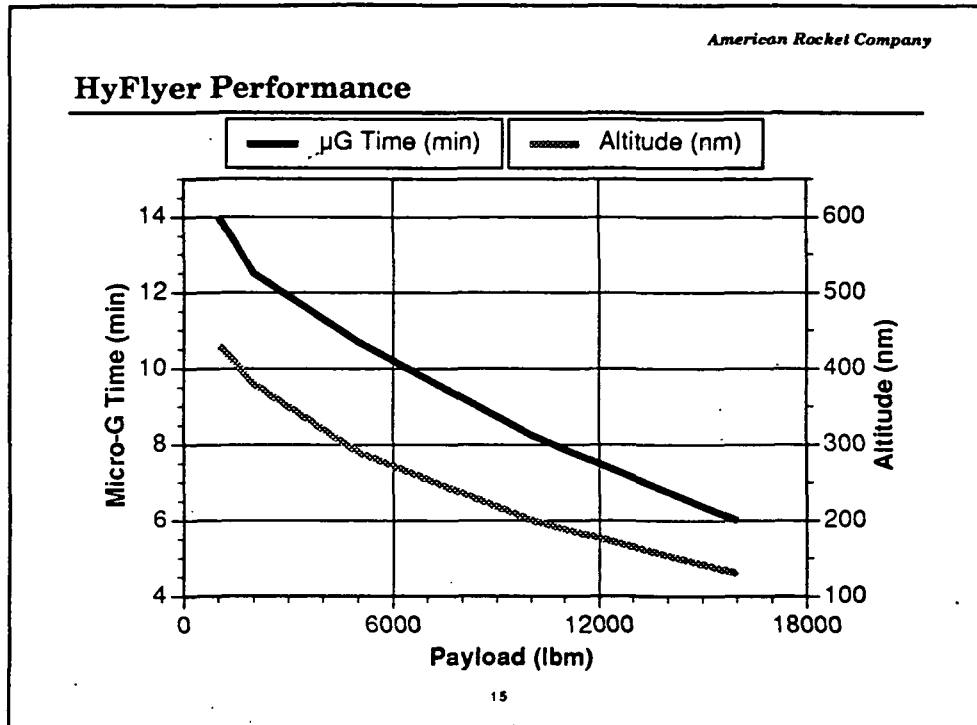
American Rocket Company

## HyFlyer Mission Profile



14

# American Rocket Company - HyFlyer Sounding Rocket Program

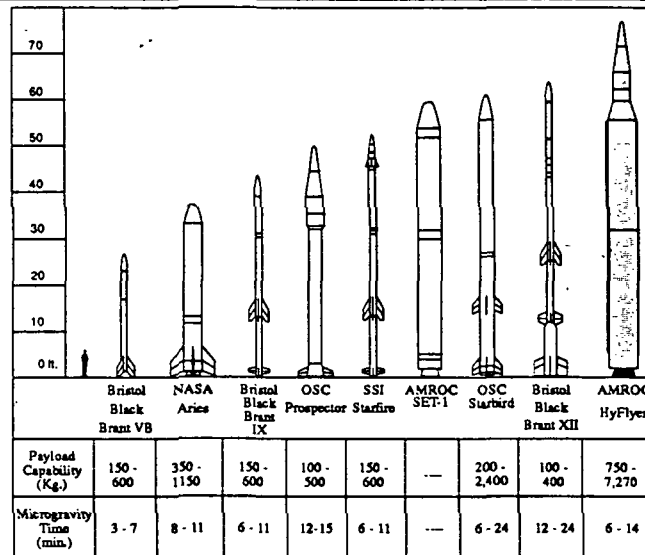




## American Rocket Company - HyFlyer Sounding Rocket Program

*American Rocket Company*

### Sounding Rocket Fleet



17

*American Rocket Company*

### HyFlyer Summary

- **AMROC's HyFlyer is the Mac Truck of Sounding Rockets**
  - Unique Heavy Lift Capability - 8 Tons!
- **72" Diameter Booster - Large Payload Volume Available**
- **Developed to Validate Hybrid Propulsion For AMROC's Orbital Vehicle - Aquila**
- **Available Late 1993**
- **Estimated Launch Cost ≈ \$3.5M**

18